Claims

What is claimed is:

1. An apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing, comprising:

an upper tubular support member defining a first passage;

one or more cup seals coupled to the exterior surface of the upper tubular support member for sealing an interface between the upper tubular support member and the expandable tubular member;

an expansion cone assembly coupled to the upper tubular support member adjustable to one expansion diameter corresponding to the desired diameter of the bell portion of the wellbore casing for forming an expanded bell portion in the expandable tubular member and adjustable to another expansion diameter corresponding to the desired diameter of the mono diameter casing for forming the mono diameter wellbore casing;

means for actuating the expandable tubular member to adjust from the one diameter to the other diameter; and

an actuator for moving the cone through the expandable tubular member a desired distance with the expansion cone assembly adjusted to the diameter of the bell portion and for moving the expansion cone assembly through the expandable tubular member for another distance with the expansion cone assembly adjusted to the desired diameter of the mono diameter portion of the expandable tubular member.

2. The apparatus of claim 1, wherein

the expansion cone assembly comprises a one adjustable cone having an external surface adjustable to the diameter of the bell portion of the expandable tubular member; and wherein

the external surface of the one adjustable cone is also adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing.

3. The apparatus of claim 1, wherein the expansion cone assembly comprises:

a first adjustable cone having an external surface adjustable to the diameter of the bell portion of the expandable tubular member; and

a second adjustable cone having an external surface adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing.

4. The apparatus of claim 1, wherein the expansion cone assembly comprises:

a first adjustable cone having an external surface adjustable to the diameter of the bell portion of the expandable tubular member and collapsible after expanding the bell portion; and

a second cone having a fixed diameter corresponding to the desired diameter of the mono diameter wellbore casing such that collapsing the first cone effectively adjusts the effective expansion diameter to the fixed diameter of the second cone.

5. The apparatus of claim 1, wherein the expansion cone assembly comprises:

an upper cam assembly coupled to the upper tubular support member comprising:

a tubular base coupled to the upper tubular support member; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the tubular support member, and each upper expansion segment movable relative to the inclined surface of one of the plurality of cam arms to adjust the radial position of an eternal surface of the segment to adjust the diameter of the expansion cone assembly;

a lower tubular support member defining a second passage fluidicly coupled to the first passage releasably coupled to the upper tubular support member;

a lower cam assembly coupled to the lower tubular support member comprising:

a tubular base coupled to the lower tubular support member; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and

a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment pivotally coupled to the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly and each lower expansion segment movable relative to the inclined surface of one of the plurality of cam arms to adjust the radial position of an eternal surface of the segment to adjust the diameter of the expansion cone assembly;

wherein the lower expansion cone segments interleave and overlap the upper expansion cone segments; and

wherein the upper and lower expansion cone segments each approximate an arcuate spherical external surface for plastically deforming and radially expanding the expandable tubular member.

6. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a tubular support member;

a adjustable expansion cone assembly coupled to the tubular support member;

an expandable tubular member coupled to the adjustable expansion cone assembly;

means for displacing the adjustable expansion cone assembly relative to the expandable tubular member; and

means for adjusting the adjustable expansion cone assembly from one effective expansion diameter to another effective expansion diameter.

7. The apparatus of claim 6, wherein the tubular support member comprises an upper tubular support member comprising an internal flange and a lower tubular support member comprising an internal flange; wherein the expansion cone comprises:

an upper cam assembly coupled to the upper tubular support member comprising:

a tubular base coupled to the upper support member; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the internal flange of the upper tubular support member;

a lower cam assembly coupled to the lower tubular support member comprising:

a tubular base coupled to the lower tubular support member; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly; and

a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment pivotally coupled to the internal flange of the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly; and wherein the apparatus further comprises:

means for releasably coupling the upper tubular support member to the lower tubular support member; and

means for limiting movement of the upper tubular support member relative to the lower tubular support member.

8. The apparatus of claim 6, further comprising:

means for pivoting the upper expansion cone segments; and

means for pivoting the lower expansion cone segments.

9. The apparatus of claim 6, further comprising:

means for pulling the adjustable expansion cone assembly through the expandable tubular member.

10. A adjustable expansion cone assembly, comprising:

an upper cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface;

a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly;

a lower cam assembly comprising:

a tubular base; and

a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments;

wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly;

a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly;

means for moving the upper cam assembly toward or away from the lower expansion cone segments to adjust the radial position of an external surface of the lower expansion cone segments; and

means for moving the lower cam assembly toward or away from the upper expansion cone segments to adjust the radial position of an external surface of the upper expansion cone segments.

11. The apparatus of claim 10, wherein the upper and lower expansion cone segments together approximate an arcuate spherical external surface.

12. The apparatus of claim 10, wherein each upper expansion cone segment comprises:

an inner portion defining an arcuate cylindrical upper surface and arcuate cylindrical lower surfaces;

an intermediate portion defining arcuate cylindrical and spherical upper surfaces and an arcuate conical lower surface; and

an outer portion defining arcuate cylindrical upper and lower surfaces; and

wherein each lower expansion cone segment comprises:

an inner portion defining an arcuate cylindrical upper surface and arcuate cylindrical lower surfaces;

an intermediate portion defining arcuate cylindrical and spherical upper surfaces and an arcuate conical lower surface; and

an outer portion defining arcuate cylindrical upper and lower surfaces.

13. The apparatus of claim 12, wherein each upper expansion cone segment is tapered in the longitudinal direction from the intermediate portion to the outer portion; and

wherein each lower expansion cone segment is tapered in the longitudinal direction from the intermediate portion to the outer portion.

14. An apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing, comprising:

an upper tubular support member defining a first passage;

one or more cup seals coupled to the exterior surface of the upper tubular support member for sealing an interface between the upper tubular support member and the expandable tubular member;

an expansion assembly coupled to the upper tubular support member adjustable to one expansion diameter corresponding to the desired diameter of the bell portion of the wellbore casing for forming an expanded bell portion in the expandable tubular member and adjustable to another expansion diameter corresponding to the desired diameter of the mono diameter casing for forming the mono diameter wellbore casing;

means for actuating the expandable tubular member to adjust from the one diameter to the other diameter; and

an actuator for moving the expansion assembly through the expandable tubular member a desired distance with the expansion assembly adjusted to the diameter of the bell portion and for moving the expansion assembly through the expandable tubular member for another distance with the expansion assembly adjusted to the desired diameter of the mono diameter portion of the expandable tubular member.

15. The apparatus of claim 14, wherein the expansion assembly comprises a expansion cone device

16. The apparatus of claim 14, wherein the expansion assembly comprises a rotary expansion device.

17. The apparatus of claim 14, wherein the expansion assembly comprises compliant expansion device.

18. The apparatus of claim 14, wherein the expansion assembly comprises a hydroforming expansion device.

19. The apparatus of claim 14, wherein:
the expansion assembly comprises an adjustable expander device having adjustable to the diameter of the bell portion of the expandable tubular member; and wherein
the one adjustable expander device is also adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing.

20. The apparatus of claim 19, wherein the adjustable expander device comprises an adjustable expansion cone device

21. The apparatus of claim 19, wherein the adjustable expander device comprises an adjustable rotary expansion device.

22. The apparatus of claim 19, wherein the adjustable expander device comprises an adjustable compliant expansion device.

23. The apparatus of claim 19, wherein the adjustable expander device comprises an adjustable hydroforming expansion device.

24. The apparatus of claim 14, wherein the expansion assembly comprises:
a first adjustable expander device adjustable to the diameter of the bell portion of the expandable tubular member; and

Rule 1.126

a second adjustable expander device adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing.

25

~~26.~~ The apparatus of claim 14, wherein the expansion assembly comprises:

a first adjustable expander device adjustable to the diameter of the bell portion of the expandable tubular member and collapsible after expanding the bell portion; and

a second expander device having a fixed diameter corresponding to the desired diameter of the mono diameter wellbore casing such that collapsing the first adjustable expander device effectively adjusts the effective expansion diameter to the fixed diameter of the second expander device.

26

~~27.~~ A method of forming a mono diameter casing in a wellbore, comprising:

supporting a first expandable tubular member in the wellbore using a tubular support member and an adjustable expansion assembly having a first diameter smaller than the inside diameter of the expandable tubular member;

injecting a fluidic material into the tubular support member;

sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member;

displacing the adjustable expansion assembly relative to the expandable tubular member and into the wellbore when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;

sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member;

adjusting the effective expansion diameter of the adjustable expansion assembly to a second diameter larger than the inside diameter of the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member;

moving the adjustable expansion assembly having the second diameter a predetermined distance into the expandable tubular member to radially expand and plastically deform a first portion of the expandable tubular member;

Rule 1.126

activating the effective expansion diameter of the adjustable expansion assembly to adjust to a second diameter smaller than the first effective expansion diameter; and

moving the adjustable expansion assembly through the expandable tubular member when the adjustable expansion assembly is adjusted to the third diameter, to thereby radially expand and plastically deform the remaining portion of the expandable tubular member.

27

28. The method of forming a mono diameter wellbore casing as in claim ~~27~~ 26 further comprising:

supporting a second expandable tubular member in the wellbore using a tubular support member and an adjustable expansion assembly having a first diameter smaller than the inside diameter of the expandable tubular member;

positioning the second expandable tubular member in the expanded first expandable tubular member with the first portion thereof overlapping the second expandable tubular member;

injecting a fluidic material into the tubular support member;

sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member;

displacing the adjustable expansion assembly relative to the second expandable tubular member and into the wellbore when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;

sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member;

adjusting the effective expansion diameter of the adjustable expansion assembly to the second diameter when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member;

moving the adjustable expansion assembly having the second diameter a predetermined distance into the second expandable tubular member to radially expand and plastically deform a first portion of the second expandable tubular member below the first portion of the first expandable tubular member;

activating the effective expansion diameter of the adjustable expansion assembly to adjust to the second diameter; and

Rule 1.126

moving the adjustable expansion assembly through the second expandable tubular member and past the portion overlapping with the first expandable tubular member when the adjustable expansion assembly is adjusted to the third diameter, and to thereby radially expand and plastically deform a second portion of the second expandable tubular member to the same diameter as the expanded remaining portion of the first expandable tubular member.

28 26
~~29.~~ The method of claim ~~27~~, wherein the adjustable expansion assembly comprises an adjustable expansion cone device

29 26
~~30.~~ The apparatus of claim ~~27~~, wherein the adjustable expansion assembly comprises an adjustable a rotary expansion device.

30 26
~~31.~~ The apparatus of claim ~~27~~, wherein the adjustable expansion assembly comprises an adjustable compliant expansion device.

31 26
~~32.~~ The apparatus of claim ~~27~~, wherein the adjustable expansion assembly comprises an adjustable hydroforming expansion device.

32
~~33.~~ A method of forming a casing in a wellbore, comprising:

inserting an expandable tubular member into the wellbore

radially expanding and plastically deforming a lower portion of the expandable tubular member to a first inside diameter; and

radially expanding and plastically deforming an upper portion of the expandable tubular member to a second inside diameter, wherein the first inside diameter is larger than the second inside diameter.

33 32
~~34.~~ The method of claim ~~33~~ further comprising :

inserting a second expandable tubular member, into the expanded expandable tubular member so that a top portion of the second expandable tubular member is overlapped by the expanded lower portion of the expanded expandable tubular member; and

Rule 1.126

expanding the top portion of the second expandable tubular member to the second diameter so that the top portion of the second expandable tubular member is expanded radially outward in the expanded lower portion of the expanded expandable tubular member.

34 32
~~35.~~ The method of claim ~~33~~, wherein the expanding the lower and upper portions of the expandable tubular members comprises expanding using an expansion cone device.

35 32
~~36.~~ The method of claim ~~33~~, wherein the expanding the lower and upper portions of the expandable tubular members comprises expanding using a rotary expansion device.

36 32
~~37.~~ The method of claim ~~33~~, wherein the expanding the lower and upper portions of the expandable tubular members comprises expanding using a compliant expansion device.

37 32
~~38.~~ The method of claim ~~33~~, wherein the expanding the lower and upper portions of the expandable tubular members comprises expanding using a hydroforming expansion device.

38
~~39.~~ A method of forming a mono diameter casing in a wellbore, comprising:

supporting a first expandable tubular member in the wellbore using a tubular support member and an adjustable expansion cone assembly having a first diameter smaller than the inside diameter of the expandable tubular member;

injecting a fluidic material into the tubular support member;

sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member;

displacing the adjustable expansion cone assembly relative to the expandable tubular member and into the wellbore when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;

sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member;

adjusting the effective expansion diameter of the adjustable expansion cone assembly to a second diameter larger than the inside diameter of the expandable tubular member when the sensed operating pressure of the injected fluidic material

Rule 1.126

exceeds a predetermined level within the second interior portion of the tubular support member;

moving the adjustable expansion cone assembly having the second diameter a predetermined distance into the expandable tubular member to radially expand and plastically deform a first portion of the expandable tubular member;

activating the effective expansion diameter of the adjustable expansion cone assembly to adjust to a second diameter smaller than the first effective expansion diameter; and

moving the adjustable expansion cone assembly through the expandable tubular member when the adjustable expansion cone assembly is adjusted to the third diameter, to thereby radially expand and plastically deform the remaining portion of the expandable tubular member.

39 38

~~40.~~ The method of forming a mono diameter wellbore casing as in claim ~~39~~ further comprising:

supporting a second expandable tubular member in the wellbore using a tubular support member and an adjustable expansion cone assembly having a first diameter smaller than the inside diameter of the expandable tubular member;

positioning the second expandable tubular member in the expanded first expandable tubular member with the first portion thereof overlapping the second expandable tubular member;

injecting a fluidic material into the tubular support member;

sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member;

displacing the adjustable expansion cone assembly relative to the second expandable tubular member and into the wellbore when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member;

sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member;

adjusting the effective expansion diameter of the adjustable expansion cone assembly to the second diameter when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member;

Rule 1.126

moving the adjustable expansion cone assembly having the second diameter a predetermined distance into the second expandable tubular member to radially expand and plastically deform a first portion of the second expandable tubular member below the first portion of the first expandable tubular member;

activating the effective expansion diameter of the adjustable expansion cone assembly to adjust to the second diameter; and

moving the adjustable expansion cone assembly through the second expandable tubular member and past the portion overlapping with the first expandable tubular member when the adjustable expansion cone assembly is adjusted to the third diameter, and to thereby radially expand and plastically deform a second portion of the second expandable tubular member to the same diameter as the expanded remaining portion of the first expandable tubular member.